Renewable and Sustainable Energy Reviews 13 (2009) 1675–1678

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Solar home systems in Botswana—Opportunities and constraints

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ARTICLE INFO

Article history:
Received 20 May 2008
Accepted 21 August 2008

Keywords:
Solar home systems
Rural communities

ABSTRACT

Lack of access to electricity grid form the main challenge facing majority of developing regions particularly in rural communities. The situation is driven mostly by the absence of electricity infrastructure in most of the developing countries particularly in rural communities. A number of developing countries are now encouraging the use of solar home systems in isolated areas. Botswana is not immune to this trend. Consequently, available evidence puts the overall contribution of solar energy to primary energy supply in Botswana to less than 1%. A plethora of factors are responsible for inhibiting rapid development of solar home systems in isolated areas in Botswana. Some major impediments often cited as causing low use of solar home systems by rural communities in Botswana include, among others, the following:

(i) Low-income status of most rural inhabitants.
(ii) Migration of house-owners from village status to lands, or cattle posts.

This paper, therefore, analyses factors that impede the rapid development of photovoltaics power generation systems in rural environments in Botswana. The analysis is based on photovoltaic power generation pilot project which was carried out in three (3) villages in Botswana, namely Kudumatse, Lorolwana and Motlhabaneng.

Contents

1. Introduction

Access to modern energy service is fundamental for social development and economic growth world-over. However, available evidence indicates that 1.6 billion people across the world have no access to modern energy service and more than 80% live in South Asia and Sub-Saharan Africa [1]. Concern has been expressed that absence of energy services is linked to many poverty indicators such as infant mortality, illiteracy, life expectancy, and total fertility rate [2]. On the basis of the above observations, efforts to improve access to affordable energy services for sustainable development and poverty eradication form the main global challenge facing the world today, particularly developing nation.

It should be noted that lack of access to modern energy resource affects mostly rural communities of developing regions, because the same groups of communities represent majority of the population in developing regions. For example, in Botswana, rural

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1364-0321/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2008.08.007

communities represent more than 70% of the country's population [3]. In Namibia, also, two-thirds of the population live in rural communities, particularly in the Northern region of the country where rainfall is relatively high [4]. It is pertinent to mention that rural communities in the majority of the developing regions depend mainly on traditional agriculture and pastoralism for their livehood. Previous studies including [5,6], revealed that rural areas are characterised by low population densities with scattered clusters of households usually inhabited by low income groups. These findings are consistent with observations made by Botswana Government Statistics Office that the average monthly income for rural residents in Botswana is below Botswana Pula (BWP) 530 per month, [3] which is equivalent to approximately US$ 87.

Based on the above observations particularly low population densities the development of electricity infrastructure network in majority of rural communities is not attractive business for private power generating and distributing companies. As a direct result of this rural electrification rate in the majority of the developing regions is low. For example, Sub-Saharan Africa recorded rural electrification rate of 7.5% compared with 51.3% for urban electrification rate in 2000 [1]. It is pertinent to mention that Botswana with a population of 1.8 million, only 0.7% of the population thus 38% enjoy connectivity to electricity grid [7]. Previous study by Ref. [8] puts the overall level of electrical access to national grid in isolated communities in Botswana to just 12%. Based on the above observations, several countries, Botswana included have implemented a wide range of energy sector reform aimed to increase access to modern energy resources in rural communities.

In Botswana the reforms focus on strategy to expand the use of photovoltaic lighting systems in rural communities. Emphasis on the use of photovoltaic systems has been reflected in a number of government policy documents. For example, The Vision 2016 which is the country's blue-print for future national aspirations spells out that the country must be developed as a centre of excellence for solar energy technology. The document further spells out clearly that solar power is a potential source of electricity for public schools in isolated communities. Botswana Energy Master Plan, first published in 1996 and reviewed in 2003 also sets out a number of goals and programmes for rural electrification using renewable energy sources. The components of the programmes are articulated as follows:

(i) Promotion of solar energy by the Botswana Government.
(ii) Integration of grid and non-grid technologies.
(iii) Encouragement of research and development with regard to renewable energy sources.
(iv) Identification of an appropriate institutional framework for rural electricity using renewable energy.
(v) Development of strategies for removing the barriers to widespread use of renewable energies.
(vi) Promotion of women and children's welfare through the provision of PV power generation (lighting) [9].

It should be stressed that presently only few of the above listed components (i, iv and v) are being implemented as reflected in Section 2. However, development of integration of national electricity grid and non-grid technology is not receiving widespread attention from energy sector. This is demonstrated by the closure of solar mini grid community power system at Motshegaletau village in 2007. The closure was driven by the extension and distribution of national electricity grid in the same village by Botswana Power Corporation [10]. It is pertinent to mention that a study by Ref. [11] reported that women and children form the majority of poor people in any community and are usually major users and suppliers of energy resources in marginalised communities. Based on this observation, particularly on component (vi) of the programmes for rural electrification, it is clear that the approach by Botswana government to increase access to modern energy in marginalised communities is pointing to the right direction.

It is further noted that the Revised National Policy on Rural Development [12], also emphasises the importance of using renewable energy resources. The policy document clearly spells out that the use of renewable energy should be encouraged as a measure to reduce harmful emissions and conserve natural resources. The same policy document further notes that the provision of energy using renewable resources is likely to promote the development of productive activities in rural communities which are not necessarily based on agriculture.

The authors believe that productive activities referred to in the Revised National Policy document include establishment of small enterprises, communication services, improved school-related activities, and improved health-related needs. All these lead to the conclusion that provision of modern energy services to marginalised communities is likely to improve their living conditions, and ultimately break the cycle of poverty by creating enhanced opportunities for education, employment and improved livehoods.

Based on the above observations, it becomes apparent that there is an urgent need for the Botswana government to respond to the lack of energy services in rural communities by providing photovoltaics systems. However, it should be stressed that despite strong government ambitions to increase the use of renewable energy resources, backed up by excellent solar conditions in Botswana, with an average of 320 clear, sunny days per year and an average global irradiation of 21 MJ m^{-2}/day throughout the country, the contribution of solar energy to primary energy supply is currently less than 1% in Botswana [13]. However, considering excellent solar conditions prevailing in the country, and low population density in rural communities as mentioned earlier, it becomes clear that the country has potential market for the use of photovoltaics. This conjures several questions, the primary one being factors which adversely affect the rapid development of photovoltaic power generation in rural environment in Botswana. Available evidence indicates that photovoltaics already provides electricity to an estimated 1 million rural households in developing countries who lack access to electricity grids [14].

This paper analyses, among others factors that impede the rapid development of photovoltaics power generation systems in rural environments in Botswana. The analysis is based on photovoltaic power generation pilot project which was carried out in three (3) villages namely Kudumatse, Lorolwana and Motlhabaneng from early-2002 by Energy Affairs Division (EAD) in collaboration with Japanese International Cooperation Agency (JICA). The overall objective of the pilot project was to assess feasibility of using photovoltaics systems for power generation in rural communities in Botswana. The paper further outlines strategies required to sustain rapid development of photovoltaic power generation systems in rural communities in Botswana.

2. Project brief

In line with the global challenge to address the issue of energy poverty among the rural communities, the Government of Botswana in collaboration with Japanese International Cooperation Agency (JICA) implemented a pilot project on PV solar system in 3 villages mentioned earlier. The pilot project started in early 2002, and was completed in December 2005. The project aimed at providing lighting for rural dwellers using PV Solar Home System (SHS) ranging from 50 to 250 Wp.

The project employed fee-for-service model. In this model an energy-service company provides electricity to households in a

community for a monthly fee. However, the model is such that the system is owned and maintained by the energy service company in the specialist area. It is pertinent to mention that rural electrifications (electricity grid) has traditionally been the responsibility of state-owned power companies that have depended on economies of scale to cross-subsidise rural electrification systems. In the present study, Botswana Power Corporation, a government owned company and the only power generation and distribution company within the country was sanctioned to monitor the implementation processes of the pilot project. Botswana Solar International Company (private company) was sanctioned to install solar home systems in all the 3 villages and monitor components performance for the first 12 months.

Although the pilot project was aimed at providing modern electricity to selected participants, the primary goal was to gather data so that the concept could be replicated in other parts of the country and the data collected during the implementation phase would serve as the basis for formulating policies on the use of solar home systems in rural communities in Botswana. It should be stressed that the preparation for introducing different PV-based technology packages in 66 villages are at advanced state [15]. On the basis of all these, the current study is expected to add new information to the proposed PV-based programmes.

3. Economic performance of the project

In order to assess the socio-economic merits of the PV pilot project in all the 3 villages mentioned earlier. In order to obtain more information on economic case of using PV systems in rural communities in Botswana, a regular monitoring of revenue collected from participants was put in place by Botswana Power Corporation. In the present study, monthly payments ranged from BPW 40 which is equivalent to approximately US$ 8 for 50 Wp system to BPW 120 which is equivalent to approximately US$ 24 for 250 Wp solar home system. At the inception stage of the pilot project a total of 114 solar home systems (SHS) were installed in all the 3 villages. However, the present study revealed that between the inception stage and August 2005, several PV solar systems were repossessed by the authority because the majority of participants could not afford to make regular payments. Table 1 presents a summary of the facilities in selected 3 villages.

One of the most discernible trends connected to Table 1 is that the majority of participants in all the 3 villages used 50 Wp solar power generation system. The trend could be linked to low income status among the rural residents as mentioned earlier in Section 1. The investigation also revealed that at the end of monitering period (August 2005) 42 out of 114 systems had been repossessed, thus 37%. This invites several questions, the primary one being the sustainability of PV solar systems in rural communities in Botswana. To pave way for subsequent discussion, Fig. 1 shows the trend in a number of households (participants) who paid operational costs (fee-for-services) for 2002 in all the 3 villages under review.

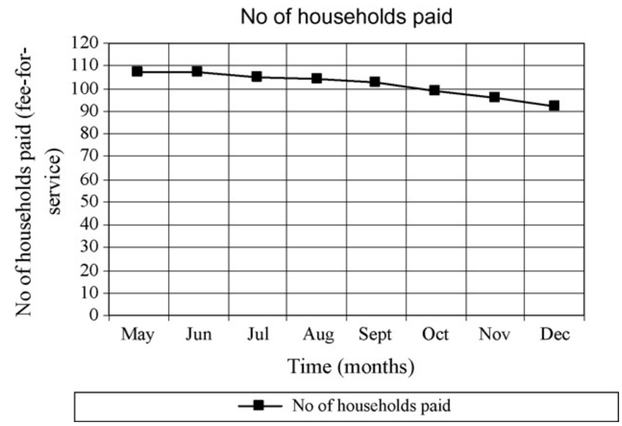


Fig. 1. Trend in number of households (participants) who paid service fees in all the 3 villages for 2002.

Overall, the data in Fig. 1 show a steady decrease with time in the number of house-owners who made regular payments for the service provided. However, the same data show that between September and December the decrease was relatively high compared with the decrease between May and August for the same year. It should be noted that the majority of households in rural communities in Botswana have three settlements, at the same time, thus lands, cattle post and village status. As such the authors believe that high decrease in the revenue recorded between September and December is because majority of participants had migrated to their lands. This observation is based on the fact that September to December is the ploughing season in Botswana. As such majority of households migrate from villages to lands, making regular payment of monthly fee problematic among rural communities. The authors contend that the trend demonstrated has a bearing on sustainability of renewable energy in rural communities in Botswana.

To further investigate the sustainability and the challenge that the use of PV solar home systems in rural communities in Botswana are faced with, the authors looked into the expected and the actual monthly revenue collected during the monitoring period for 2 villages, namely Motlhabaneng and Kudumatse. Fig. 2(a) and (b) shows trends in revenue collection from residents of Motlhabaneng and Kudumatse villages.

It should be stressed that during the monitoring period, 42 PV solar home systems were repossessed from the participants in all the three villages, because of the reason cited earlier on in the same section. Considering the data presented in Table 1, it is clear that residents of Lorolwana were mostly affected, with 25 out of 40, thus 63%. This compares with 21 and 17% levels of repossession for Kudumatse and Motlhabaneng Village respectively. For this reason, no data for Lorolwana village can be included in Fig. 2. The situation suggests that there are significant economic

Table 1
Summary of solar home systems in selected villages

System size	Village								
	Kudumatse			Lorolwana			Motlhabaneng		
	Initial	Repossessed	Present	Initial	Repossessed	Present	Initial	Repossessed	Present
50 Wp	30	8	22	35	21	14	23	5	18
100 Wp	7	1	6	4	4	0	7	1	6
150 Wp	2	1	1	1	0	1	1	0	1
200 Wp	1	1	0	–	–	–	–	–	–
250 Wp	–	–	–	–	–	–	3	0	3
Total	40	11	29	40	25	15	34	6	28

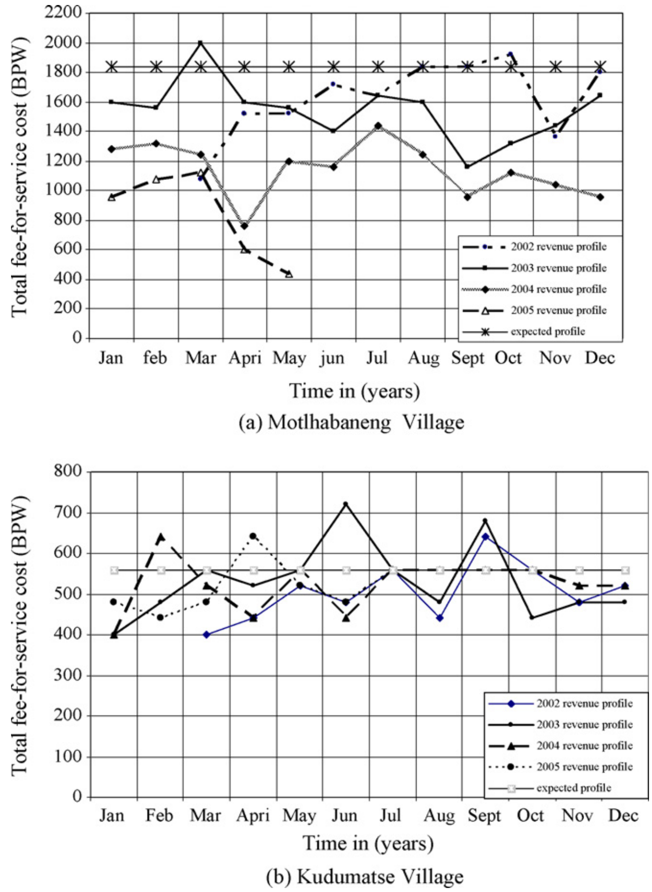


Fig. 2. Summary of total fee-for-service revenue collected on monthly basis from (a) Motlhabaneng and (b) Kudumatse.

variations among rural communities in Botswana, which energy policy should focus on in order to provide rapid and effective development of the use of solar technology power generation systems in isolated communities.

The data in Fig. 2(a) show that monthly revenue (fee-for-service cost) collected during the first four (4) years from participants at Mothabaneng village is well below the expected revenue of approximately BWP 560, which is equivalent to US$ 112. The data show that revenue recorded during 2002–2005 decreased with time, with 2005 recording a minimum of approximately BPW 400, thus 78% below the expected target. The data in Fig. 2(b) also show that the revenue recorded for Kudumatse during the monitoring period are still below the expected target. The data also show that the actual monthly figures range from BPW 504 to 523 per month, thus 10 to 7% below the expected monthly target.

Based on the above observation, and particularly on the results in Figs. 1 and 2, it is perhaps appropriate to observe that the fee-for-service model is an unsuitable model to be used by the authority to stimulate development of solar power generation in most rural communities in Botswana. The trend demonstrated in Fig. 2 is unlikely to stimulate the private sector to invest in the area of renewable technology in rural communities in Botswana.

The issue of unsuitable model (fee-for-service) is reinforced by observations from interviewees who revealed that the majority of residents were not willing to make payment for the period there were either at lands or cattle post. The authors contend that fee-for-service payment system has a bearing on high level of system repossession by the Energy Affairs Division. The challenge for the government of Botswana is to formulate PV programmes which take into account a wide spectrum of economic variations among rural residents in Botswana. Considering the benefits of access to modern energy as indicated earlier it is.

4. Conclusion and recommendations

This paper has examined the status of PV solar pilot project in three villages in Botswana. In particular, the study revealed that 37% of the participants defaulted from paying the running costs (fee-for-service cost). The average monthly revenue recorded during the first 4 years monitoring period for all the two villages is well below the expected target. It can be concluded further that migration of householders from village status to lands or cattle posts among rural communities in Botswana has a direct bearing on sustainability of fee-for-service model in rural residents in Botswana.

The following measures are therefore, proposed as likely to go a long way in stimulating sustainability of solar home systems in rural communities in Botswana:

(i) Simultaneous with encouraging the use of solar home systems in rural communities in Botswana, authorities should provide flexible terms of payments and more PV solar based programmes solar lanterns included. This approach is likely to significantly, reduce rate of defaulters and increase the number of house-owners using PV systems for power generation.
(ii) To assist sustainability of PV solar power generation in rural communities, there should be variations in fee-for-service costs based on economic status of individual house-owners or communities.
(iii) To enhance socio-economic benefits, and to foster sustainability of using PV solar power generation systems in rural communities in Botswana, authorities should increase the level of subsidy on the use of solar technology.

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